

Aluminum nitride sintered bodies according to the examples 22 to 33 have low volume resistivities not higher than  $1 \times 10^{13} \Omega \cdot \text{cm}$  at room temperature and the differences of the resistivities at room temperature and 300 °C were small. Low activation energies not higher than 0.4 eV were also obtained.

The sintered bodies according to the comparative examples 9 and 10 contained large amounts of the second rare earth elements forming complex oxides, providing a higher volume resistivity and a higher activation energy of temperature dependency of the resistivity.

Fig. 11 shows the temperature dependency of volume resistivity of the sintered body in each of the examples 22 and 30 and comparative examples 9 and 10, as representative samples showing resistivity change at a high temperature range. It is thereby possible to properly operate an electrostatic chuck within a wide temperature range of about 60 to 500 °C, when the sintered body of the example 30 is used as a substrate of the chuck.

Further, the properties of the sintered bodies according to the examples 22 to 33 were compared with those of the bodies according to the examples 6 and 7 without the addition of the second rare earth element.

When  $\text{Yb}_2\text{O}_3$  was added (examples 22 and 33), or  $\text{Dy}_2\text{O}_3$  was added (examples 30 and 31), or  $\text{Er}_2\text{O}_3$  was added (examples 32 and 33), the resistivity may be slightly increased and the strength may be improved, by adding 0.04 to 0.05 mole percent of the rare earth oxide. Especially in the examples 22, 30 and 32, it was possible to lower the sintering temperature to 1750 °C and to obtain a dense body still maintaining a mean grain diameter at about 3  $\mu\text{m}$ . It was thereby possible to attain a strength higher than 520 MPa.

When  $\text{La}_2\text{O}_3$  was added (example 28), the content of  $\text{La}_2\text{O}_3$  was 0.015 mole percent, the molar ratio of the content of  $\text{La}_2\text{O}_3$  / content of  $\text{Sm}_2\text{O}_3$

was 0.18 and the volume resistivity was  $4 \times 10^{12} \Omega \cdot \text{cm}$ . It was thereby possible to increase the volume resistivity by adding a smaller amount of the second rare earth element compared with the compositions with the other second rare earth element added. Moreover, the thus obtained sintered body has a strength higher than 500 MPa.

It is also possible to slightly increase the resistivity by adding  $\text{CeO}_2$  (examples 24, 25 and 26) or  $\text{Y}_2\text{O}_3$  (example 27), as the other formulations.

In each of the above examples, the thermal conductivity of the sintered body is not lower than 100 W/mK and exhibits a high thermal conductivity.

$\text{SmAl}_{11}\text{O}_{18}$  phase and  $\text{SmAlO}_3$  phase were identified as the intergranular phase, in addition to the main phase ( $\text{AlN}$  phase), in each of the above sintered bodies. In some examples, a trace amount of a crystalline phase of  $\text{Re}_3\text{Al}_5\text{O}_{12}$  type (Re is a rare earth element) was identified.

In the intergranular phase of each sintered body according to the examples 22 to 33, the distribution of the elements was substantially same as that shown in Fig. 6, and Sm containing phase is formed along the intergranular phase between  $\text{AlN}$  particles, forming network microstructure.

Fig. 12 shows X-ray diffraction profiles of the sintered bodies according to the examples 24 and 25 and comparative examples 9 and 10. In the examples 24 and 25 and comparative examples 9 and 10, as shown in table 8, the amount of  $\text{Sm}_2\text{O}_3$  was maintained constantly and the amount of  $\text{CeO}_2$  is increased stepwise when formulating the raw mixed powder. In Fig. 12, the diagrams of the examples 24, 25, and comparative examples 9, 10 were arranged vertically in series. Peak "C" is a representative peak of  $\text{SmAl}_{11}\text{O}_{18}$  phase and peak "D" is a representative peak of  $\text{SmAlO}_3$  phase.  $\text{CuK}\alpha$  ray and current of 50 kV and 300 mA were used.

Figs. 13, 14, 15 and 16 show backscattering electron images of polished surfaces of the sintered bodies according to the examples 24 and 25 and comparative examples 9 and 10. The brighter the image is, the larger the content of atoms with large atomic numbers. Therefore, a larger amount of samarium atoms or the second rare earth atoms are present in a brighter region in the image.

In Fig. 13, blackish particles are identified as AlN particles. The intergranular phase is composed of the two phases: white and dispersed (isolated) phase, and gray, elongate and continuous phase mainly constituting network microstructure. It is considered that the white and dispersed phase is mainly composed of SmAlO<sub>3</sub> phase, by comparing the distribution of lightness in intergranular phase and Fig. 12. The gray and elongate intergranular phase, mainly constituting network microstructure, has a lightness lower than that of the dispersed phase, indicating that the contents of Sm and the other rare earth element are lower. It is therefore considered that the elongate and network shaped phase is mainly composed of SmAl<sub>11</sub>O<sub>18</sub> phase.

The network microstructure, same as that shown in Fig. 13, may be recognized in Fig. 14 (example 25). Further, SmAl<sub>11</sub>O<sub>18</sub> phase and SmAlO<sub>3</sub> phase may be identified in X-ray diffraction diagram of Fig. 12.

In Fig. 15 (comparative example 9), the amount of cerium was increased. In the example, intergranular particles with a high lightness are grown to form large particles and are unevenly distributed. The gray and elongate continuous phase is almost diminished. Consequently, the network microstructure shown in Figs. 13 and 14 may not be easily recognized. Responsive to this change, in X-ray diffraction diagram in Fig. 12, the strengths of characteristic peaks of SmAlO<sub>3</sub> phase are slightly increased and the strengths of characteristic peaks of SmAl<sub>11</sub>O<sub>18</sub> phase are considerably